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# COL.D.D.

## Cold Water Swimming for Dementia and Depression Prevention

Project Number: 101133918

*COL.D.D. - D4.1 Research Paper*

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## Abstract

The COL.D.D. Project - Cold Water Swimming for Dementia and Depression Prevention (Project number: ERASMUS-SPORT-2023-SCP-101133918), funded by Erasmus+ Sport Program of the European Commission, is aimed at enhancing social inclusion and mental well-being among middle-aged and older adults through a non-pharmacological and integrative intervention. The ten workshops program combined mindfulness training with cold-water immersion, targeting depressive symptoms, anxiety and executive functioning, key factors in age-related cognitive decline.

A total of 46 participants from five countries (Italy, Austria, Belgium, Croatia, and the Czech Republic) attended the structured twice-monthly sessions facilitated by psychologists and trained instructors. The impact was evaluated following a pre-post study design through standardized, validated self-report measures: the **Beck Depression Inventory** (BDI) for depressive symptoms, the **State-Trait Anxiety Inventory** (STAI-S) for state anxiety, and the **Amsterdam Executive Functioning Inventory** (AEFI) for perceived executive functioning and a **Qualitative Interview** developed in the contest of the project to measure changes in mood, physical activity, and overall quality of life.

The results demonstrated a statistically significant reduction in depressive symptoms ($t = 3.40$, $p < 0.001$) and state anxiety ($t = 2.88$, $p < 0.01$), along with a moderate improvement in executive functioning ($t = –2.40$, $p < 0.05$). These changes were particularly pronounced among middle-aged adults (45–59 years), suggesting that this age group may benefit most emotionally from such interventions.

Complementing these findings, qualitative feedback from participants revealed increased energy, motivation and emotional balance and a reported improved life satisfaction without major shifts in clinical symptoms.

Taken together, the results support the preventive role of body–mind approaches in enhancing mental health and cognitive well-being during aging. The COL.D.D. project presents a replicable model for interdisciplinary and culturally adaptable psycho-cognitive health promotion. Future studies should explore long-term adherence and extend assessment to include objective cognitive and physiological measures, such as sleep quality and neuroendocrine responses.

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## 1. Introduction

The **COL.D.D. project** (*Cold Water Swimming for the Prevention of Dementia and Depression*) is a European initiative co-funded by the **Erasmus+ Sport Program**. It was developed in response to the increasing mental health and cognitive challenges faced by middle-aged and older adults. The project promotes a **non-pharmacological and holistic intervention** based on structured **cold-water immersion (CWI)** combined with **mindfulness practices** and **breath control techniques**.

The project is the result of a transnational partnership involving five European organizations: **CEIPES ETS** (Italy), the **European Network of Active Living for Mental Health - ENALMH** (Belgium), the **Innovative Education Center - IEC** (Austria), **PK Zagreb** (Croatia), and **Shut Up and Swim** (Czech Republic), with the **University of Palermo** as an associated partner of the project. Together, the consortium designed and implemented a 10 week program targeting adults aged 45 and older, with the dual goal of promoting mental well-being and preventing age-related cognitive decline.

## 2. Scientific Rationale and background

In recent years, scientific interest in cold water immersion has extended beyond the realm of sports recovery to include potential therapeutic benefits for mental health and cognitive function. Initially employed for its anti-inflammatory and muscle recovery properties (Bleakley et al., 2012), CWI has more recently been studied for its systemic effects on the autonomic nervous system and hypothalamic–pituitary–adrenal (HPA) axis, with implications for mood stabilization and enhanced stress resilience (Kox et al., 2014).

A growing body of theoretical and empirical evidence supports the hypothesis that cold exposure may produce neurobiological changes conducive to emotional well-being. For example, Shevchuk (2008) proposed that stimulation of thermoreceptors during cold water immersion activates the sympathetic nervous system, resulting in increased plasma concentrations of noradrenaline and beta-endorphins, neurochemicals implicated in mood regulation and the reduction of depressive symptoms. More recently, Almahayni and Hammond (2024) conducted a meta-analysis confirming that combined breathing techniques and CWI are associated with significant reductions in anxiety and depressive symptoms, as well as improvements in attentional control and working memory.

These findings are particularly relevant in the context of aging, a life stage characterized by increased vulnerability to mood disorders and cognitive decline. Late-life depression, often underdiagnosed and undertreated, is a major contributor to reduced functional autonomy and increased risk of dementia (Fiske et al., 2009). Anxiety frequently co-occurs, further complicating clinical outcomes. Moreover, executive functions, referring to cognitive processes such as planning, self-monitoring, inhibition, and mental flexibility, often deteriorate even in the absence of neurodegenerative disease, impacting quality of life and daily functioning.

The COL.D.D. project is designed to empirically evaluate the effects of a structured intervention involving cold water immersion combined with guided breathing exercises in a sample of adults and



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older individuals. Outcome measures include validated psychometric scales assessing mood and anxiety (the Beck Depression Inventory, the State-Trait Anxiety Inventories), quality of life indicators with an appropriately designed qualitative questionnaire, and executive functioning (Amsterdam Executive Functions Inventory).

Notably, cold exposure has been shown to modulate limbic activity, reduce perceived stress, and enhance parasympathetic tone. Reed et al. (2023) reported that regular exposure to cold water significantly reduced anxiety symptoms in adults with chronic stress. In parallel, studies by Kox et al. (2014) demonstrated the activation of higher-order brain regions such as the prefrontal cortex following breathing exercises and thermal stress, supporting the rationale for potential cognitive benefits.

In conclusion, the COL.D.D. project reflects a broader trend toward integrative and preventive medicine by introducing a low-cost, replicable, and side-effect-free method for supporting psychological and cognitive health in aging populations.

This report has therefore the aim to illustrate the literature behind the COL.D.D project, the structure of the study and the results obtained thanks to the intervention.

**Why is it relevant?**

The issue of an aging population is well-documented in the scientific literature. In 2010, 16.2% of the global population was aged 65 or older; this proportion is projected to rise to 26.9% by 2050. As life expectancy continues to increase, the importance of maintaining both physical and mental health in later life becomes ever more critical.

Aging is often accompanied by a growing need for medical care and a higher prevalence of chronic, age-related illnesses. However, the challenges of aging extend beyond physical complications. Older adults frequently experience psychological and emotional distress, which can significantly impact their mental well-being. Depression, in particular, is a leading cause of disability among older adults. It is closely linked to cognitive and physical decline, reduced quality of life, and increased mortality risk.

From a public health perspective, identifying preventive and non-pharmacological interventions that support emotional and cognitive resilience is essential. This is where the **COL.D.D. initiative becomes highly relevant**.

The project specifically targets three key dimensions of mental and cognitive health in aging:

1. **Depression**,
2. **Anxiety,**
3. **Executive functioning**.



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Each of these variables plays a crucial role in late-life health trajectories.

- **Depression** is not only a common mood disorder in older adults, but also a risk factor for accelerated cognitive decline and the development of neurodegenerative diseases. By addressing depressive symptoms through practices such as mindfulness and cold-water exposure, the project aims to foster more stable mood regulation and reduce long-term vulnerability.
- **Anxiety**, particularly state anxiety, can further exacerbate emotional distress and impair attention, working memory, and decision-making. Given its association with heightened physiological stress responses, interventions that improve stress regulation — such as breath control and gradual cold-water adaptation — may help reduce anxiety levels in the short and long term.
- **Executive functioning** refers to high-level cognitive processes such as planning, inhibitory control, and cognitive flexibility, which are critical for maintaining independence in daily life. Declines in executive functioning, even in the absence of diagnosed dementia, are associated with increased fall risk, social withdrawal, and reduced quality of life. The COL.D.D. program hypothesizes that combining mindfulness-based cognitive training with physiological stimulation from cold exposure may enhance or preserve these abilities.

What makes this initiative particularly innovative is its **integrated and accessible approach**. Rather than treating symptoms after deterioration has occurred, the project promotes a proactive, preventive model of mental health, one that is **low-cost, non-invasive, and community-based**. It is designed not only to alleviate symptoms, but also to **empower participants with techniques** they can continue using autonomously beyond the structured program.

In this sense, COL.D.D. aligns with broader goals in active and healthy aging policy by providing concrete tools to support **psychological resilience**, **cognitive health**, and **social inclusion**, all of which are essential to reducing the burden on healthcare systems and improving quality of life in later years.

## 3. Materials and Methods

### 3.1 Participants

People joined the project voluntarily after seeing public announcements in five different countries: Italy, Croatia, Austria, Belgium, and the Czech Republic. The recruitment was part of the COL.D.D. project –*Cold Water Swimming for Dementia and Depression Prevention*.

The COL.D.D. project is a European initiative carried out by a team of organizations from different countries: CEIPES ETS (Italy), the European Network of Active Living for Mental Health (Belgium), Swimming Club Zagreb (Croatia), SHUT UP AND SWIM (Czech Republic), and the Innovative Education Center (Austria), with support from the University of Palermo.

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The main goal of the project is to promote **inclusion and healthy lifestyles**, especially among people who are socially isolated or belong to vulnerable groups. The activities included in the program aim to improve well-being through **mindfulness, breathing exercises and cold-water immersion**. These methods were chosen because they're all seen as natural, drug-free ways to prevent or reduce depression and early signs of dementia.

At first, 54 people signed up, but 8 of them dropped out before finishing. In the end, the study involved **46 participants**, of whom **63% were women**, with an average age of **60.67 years** (±8.51). Most were married, and they lived across the five participating countries. The majority of them were retired.

Participants were asked to fill in questionnaires before and after the training period. These questionnaires focused on how they felt about their **mental well-being, mood (depression and anxiety)**, and **everyday thinking abilities** (like planning or staying focused).

The training lasted from **November 2024 to March 2025**, with **two sessions per month**, each about **two hours long**, for a total of **ten sessions per partner**. The majority of participants completed the full program.

### 3.2 Procedures

Participants were recruited through the networks of the partner organizations involved in the project. The intervention followed a pre–post design: participants first completed a battery of standardized questionnaires, followed by their participation in a series of 10 structured workshop sessions, delivered bimonthly between November 2024 and March 2025.

Each workshop was organized into two main components. The first part consisted of guided mindfulness practices, including relaxation techniques, breathing exercises, and meditation, aimed at fostering emotional regulation and mental focus. In the second part, participants engaged in Cold Water Immersion (CWI), a gradual exposure to cold temperatures designed to stimulate physiological stress adaptation.

The specific modality of CWI varied across countries to reflect local environmental conditions and resources. In some cases, participants used cold-water tubs, ice baths or pools while in others, immersion took place in natural water bodies such as the sea. Throughout the workshops, the duration and water temperature of the immersions were progressively adjusted. As participants became more confident and physiologically adapted to the practice, they were able to tolerate colder temperatures and longer immersion times, reflecting a gradual acclimatization process.

Quantitative and qualitative assessments were administered both at the start and at the conclusion of the intervention period, allowing for the evaluation of emotional, cognitive, and experiential changes associated with the training program.



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### 3.3 Instruments

**Executive Functions.** For measuring the Executive Functions of participants in the study The Amsterdam Executive function Inventory (AEFI, Van der Elst *et al.*, 2012) was the scale chosen. The scale is conceptualized in the present study as comprising three distinct and separable components. The first component, Attention, includes cognitive abilities such as selective and sustained attention. This is assessed through items such as "I am not able to focus on the same topic for a long period of time" and "My thoughts easily wander." The second component reflects Working Memory and Self-Monitoring abilities. The third and final factor is Planning and Initiative, evaluated with items like "I can make fast decisions" and "I am full of new ideas." For the purpose of the study, it was decided to follow the single-factor structure of the scale, and consider the general score, obtained through the raw sum of all the items. The internal consistency of the scale was 0.54, which is in line with the original standardization of the questionnaire.

**Anxiety.** For measuring the perceived anxiety of participants was used the "State Trait Anxiety Inventory Scale" (STAIS - 5 and STAIT - 5 Zsido *et al.*, 2020). The present study utilized the short-form versions of the State Trait Anxiety Inventory (STAI; Spielberger et al., 1970), specifically the subscale that measures State Anxiety STAIS-5. Each version consists of five items assessing different aspects of anxiety. The STAIS-5 measures state anxiety, reflecting the participant's current level of anxiety at the time of assessment. The STAIT-5 assesses trait anxiety, a more stable characteristic that represents the participant's general tendency to experience anxiety over time. The internal consistency of the scale was good (Cronbach alpha: 0.81).

**Depression.** To measure depression levels among participants this study used the Beck Depression Inventory Short Version (Chibnall & Tait, 1995). The version used in this study of the BDI counted a total of 13 items with a Likert type response from 0 which was the minimum to a maximum of 3. The scale served as a method to measure indicators of depression. The scale showed an excellent internal consistency (Cronbach alpha: 0.96).

**Qualitative Interview.** The qualitative component of the COL.D.D. project involved the use of a structured open-ended questionnaire developed by the project consortium. The tool was designed to capture participants' personal experiences, perceptions, and reflections across various aspects of their mental, cognitive and physical well-being, before and after taking part in the intervention.

The questionnaire consisted of **22 open-ended questions**, divided into **seven thematic sections**:

1. **General Information**. Demographic data including age, gender, marital status, and occupation.
2. **Mood**. Self-perceived emotional state, including overall mood, episodes of feeling down, and factors affecting mood.
3. **Daily Activities (ADL & IADL)**. A description of participants' typical daily routines, and difficulties with both basic and instrumental activities of daily living.
4. **Orientation and Driving**. Ability to navigate familiar and unfamiliar environments, confidence in driving, and memory for routes.



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5. **Energy and Sleep**. General energy levels, sleep quality, and perceived changes in fatigue or restfulness.
6. **Recurring Thoughts**. Presence of repetitive or intrusive thoughts, their emotional impact, coping strategies, and use of professional support.
7. **Physical Activity and Barriers**. Level of physical activity, participation in sports, and obstacles that limit physical engagement.
8. **Additional Comments**. An open space for any other remarks participants wished to share.

## 4. Results

Before diving into the outcomes, it is worth explaining how the data was analyzed. The responses from the questionnaires were examined using the software R (version 4.4.1). The study followed a simple structure: participants completed a set of questionnaires before and after taking part in the program. This allowed the research team to compare how people were feeling and functioning at the start versus the end of the training.

The results showed clear improvements in all the areas the project focused on. In simple terms, participants felt better after taking part in the program. Specifically:

- **Depressive symptoms** went down significantly.
- **Feelings of anxiety** were reduced.
- **Executive functioning** — that is, how well people could manage tasks, focus, and stay mentally sharp — improved.

In the next paragraphs will be explained in detail how each of the variables presented in the study evolved and connected with each other.

## 4.1 Demographic and background information

Understanding who took part in the COL.D.D. study is essential. The characteristics of participants, their age, gender, marital status, country, and occupation, are not just descriptive: they directly influence how people experience emotional distress, cognitive changes, and how they may respond to interventions like cold-water immersion and mindfulness.

### 4.1.1 Age

Age is one of the strongest predictors of psychological and cognitive health. As we age, we often experience increased vulnerability to loneliness, chronic illness, and cognitive decline. However, research shows that older adults also report higher levels of emotional resilience and life satisfaction compared to younger individuals, a phenomenon often called the "paradox of aging" (WHO, 2022, Clarkin et al, 2024).



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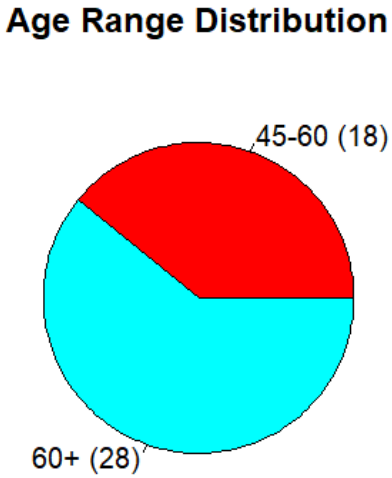
Middle-aged adults (roughly 45–59 years old) face a different set of challenges. This period is often marked by work-related stress, caregiving responsibilities, and the early signs of age-related health issues. These stressors can elevate the risk of anxiety, depression and burnout, making this group particularly important to include in preventive mental health studies (Haghighi et al., 2025).




To better understand how age might influence the program's impact, participants were divided into two age groups: middle-aged adults (aged 45–59) and older adults (aged 60 and over).

**Distribution:**
The average participant age was 60.7 years, with two subgroups:

- Middle-aged adults (45–59)
- Older adults (60+)

This distinction allowed us to investigate whether age influenced the effectiveness of the COL.D.D. intervention.

### 4.1.2 Gender

Gender is a well-established factor in emotional well-being. Women are significantly more likely to report symptoms of depression and anxiety, while men may underreport or express emotional distress through behavioral symptoms (e.g., irritability, avoidance) rather than through traditional mood indicators.

A 2023 UK survey revealed that nearly 1 in 4 women experienced a common mental health condition, compared to 1 in 6 men (The Guardian, 2023). This highlights how gendered social roles, expectations, and even biological differences may influence how distress manifests, and how it may respond to interventions like mindfulness or cold exposure.



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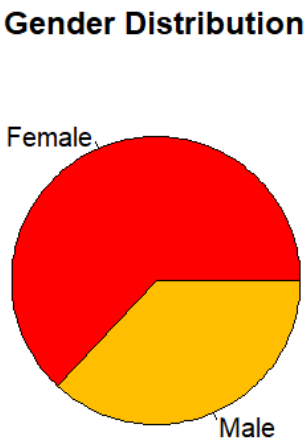



**Distribution:**

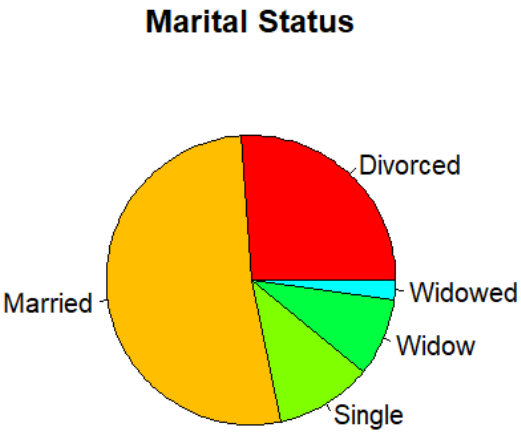
- Female: 63%
- Male: 37%

Having a majority-female sample is common in health-related studies and reflects broader trends in help-seeking behaviors.

### 4.1.3 Marital Status

Social relationships are a strong protective factor against mental illness. Being married or in a stable relationship is consistently associated with lower levels of depression, improved cognitive function, and reduced mortality risk, particularly in older adults (Holt-Lunstad et al., 2010) . In contrast, people who are divorced, widowed, or living alone tend to be more vulnerable to social isolation, loneliness, and the associated cognitive decline.

The impact of social bonds becomes even more relevant in aging populations, where loss and isolation are more common. Programs like COL.D.D. may provide not only mental stimulation but also social connection through group-based activity, helping to buffer against these risks.




**Distribution:**

- Married: 52%
- Divorced: 26%
- Single: 11%
- Widowed: 11%

This variety allowed the study to explore how relationship status interacts with psychological and cognitive outcomes.

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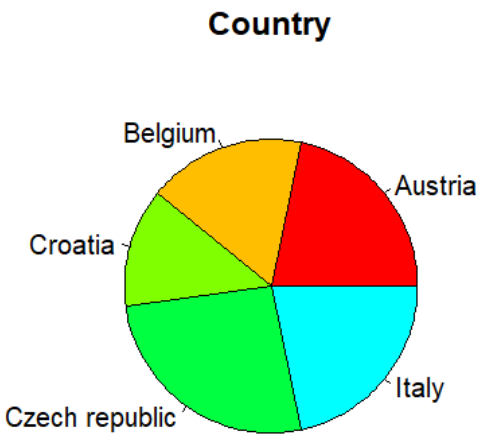
### 4.1.4 Country

The COL.D.D. project was designed as a transnational initiative. Participants were recruited from five European countries with different health systems, cultural attitudes, and levels of exposure to cold-water practices.

Cultural context matters: for example, swimming in cold water is more common and socially accepted in Central and Northern Europe than in Southern Europe. Moreover, access to mental health resources, social attitudes toward emotional expression, and lifestyle habits all vary significantly across countries (Knechtle et al, 2020).

Including a diverse set of countries helps determine whether the program's effects are consistent across cultures or if they are influenced by local factors.




**Distribution:**

- Austria: 22%
- Belgium: 17%
- Croatia: 13%
- Czech Republic: 26%
- Italy: 22%

This diverse representation supports the generalizability of the result.

### 4.1.5 Occupation

Whether someone is employed, unemployed, or retired has major implications for their mental and cognitive health. Work can provide social contact, cognitive engagement, and routine, all factors that protect against depression and cognitive decline. However, it can also be a source of chronic stress.

Retirement, on the other hand, can bring freedom but may also lead to a lack of structure or social withdrawal especially in individuals who were very career-oriented or isolated (Segel-Karpas et al., 2018).

Understanding how occupational status influences response to the COL.D.D. training helps assess whether the program supports well-being across different lifestyles and daily routines.

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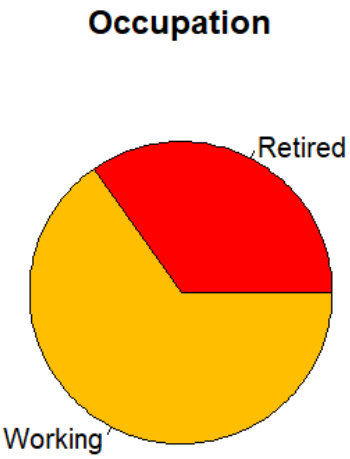


**Distribution:**

- Retired: 35%
- Working: 65%

The high proportion of retired individuals is typical for interventions targeting aging and prevention of cognitive decline.

## 4.2 Major Results

The results showed clear improvements in all the areas the project focused on. In simple terms, participants felt better after taking part in the program. Specifically:

- **Depressive symptoms** went down significantly.
- **Feelings of anxiety** were reduced.
- **Executive functioning**, that is, how well people could manage tasks, focus and stay mentally sharp, improved.

### 4.2.1 - Depression

Depression in later life is often underdiagnosed, yet it is one of the most serious threats to healthy aging. It increases the risk of physical decline, accelerates cognitive impairment, and contributes to social withdrawal and mortality. Among middle-aged adults, depressive symptoms are frequently tied to work stress, family responsibilities, and health transitions. Among older adults, they are often linked to isolation, chronic illness, and loss.

What makes depression particularly harmful in aging populations is that it can subtly undermine self-care, motivation and cognitive performance. Furthermore, its symptoms are sometimes mistaken for “normal” aspects of aging, leading to delayed treatment or neglect. Studies show that late-life depression is strongly associated with increased risk of Alzheimer’s disease and other forms of dementia (Fiske et al., 2009).

Fortunately, a growing body of evidence supports the effectiveness of non-drug approaches like mindfulness and cold exposure. Mindfulness-based programs reduce rumination, regulate emotional reactivity, and activate brain regions associated with mood stability. Cold exposure, meanwhile, stimulates a physiological stress response that, when repeated, leads to increased

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resilience and improved baseline mood through changes in neurotransmitter levels, particularly endorphins and noradrenaline (Keng et al., 2011; Shevchuk, 2008).

Before starting the program, many participants reported experiencing symptoms of depression, especially among the middle-aged group. After completing the training, their scores dropped noticeably. This means that they were feeling less sadness, hopelessness or lack of motivation. Statistically, this change was significant (**t=3.40, p<0.001**), showing that the program likely played a strong role in this improvement.

In fact, participants who were between 45 and 59 years old benefited the most. Their depression levels were clearly higher to begin with, but they also showed the greatest improvements. This suggests that this kind of training could be especially useful for adults in midlife who are starting to feel overwhelmed or mentally drained.

### 4.2.2 Anxiety

Anxiety is a common but often silent companion in adult life. It can manifest as restlessness, irritability, trouble sleeping or difficulty concentrating. Unlike chronic clinical anxiety, state anxiety refers to the temporary, situational feelings of worry or tension—precisely the type of distress that affects daily functioning but often goes untreated, especially among older adults.

Chronic low-level anxiety in aging has been associated with cardiovascular issues, weakened immune function and cognitive decline. Moreover, it tends to co-occur with other conditions, such as depression or insomnia, amplifying its impact. For this reason, addressing anxiety in non-invasive and preventive ways is a public health priority.

Research suggests that cold exposure may help regulate the autonomic nervous system and support vagal tone, essentially calming the body's stress response. When paired with breath control and focused attention, the result is improved emotional regulation and a greater sense of control over internal states (Richer et al., 2022; Jdidi et al., 2024).

Anxiety, especially situation-based anxiety (called "state anxiety"), also decreased after the training. Many people started the program feeling tense or on edge. After three months, they reported feeling more relaxed and in control. The statistical test confirmed this reduction (**t=2.88, p<0.01**).

If anything, middle-aged adults exhibited higher anxiety levels at baseline. However, unlike the pattern observed for depression, anxiety reduction was more uniformly distributed across age groups, suggesting comparable improvements among both younger and older participants.



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### 4.2.3 - Executive functioning

As people age, the cognitive flexibility, attention, and ability to manage daily tasks often decline. These capacities, collectively known as executive functioning, are fundamental for maintaining independence and quality of life. Executive functioning helps us plan, stay organized, adapt to change and regulate our emotions. Its deterioration, even in the absence of dementia, can increase vulnerability, reduce autonomy and affect well-being in subtle but meaningful ways.

Preserving executive function in midlife and older adulthood is crucial. Research shows that these abilities are directly associated with brain health and can predict functional outcomes such as mobility, social engagement, and the capacity to manage chronic illness. In fact, higher executive functioning in older adults has been linked to reduced risk of institutionalization and better health-related quality of life (Zelazo & Carlson, 2012, Yuan & Raz, 2014).

Lifestyle interventions—especially those combining cognitive and physiological components—are gaining recognition as effective, non-pharmacological strategies to preserve these abilities. Mindfulness has been shown to enhance attentional control and working memory through its effect on the prefrontal cortex. Similarly, cold-water immersion increases arousal, alertness, and noradrenaline release, which may support cognitive speed and flexibility (Tang et al., 2015, Shevchuk, 2008).

While the improvement here was smaller than for mood symptoms, there was still a **positive change**. People scored better on tests that asked about their ability to stay focused and organized in daily life. The improvement was statistically significant (**t=-2.40, p<0.05**).

## 4.3 Differences Between Genders

Individual differences such as gender can influence how people respond to mental health interventions. Biological, psychological, and social factors all contribute to shaping how men and women experience mental health challenges and respond to practices like cold-water exposure and breathwork (Albert, 2015). The following section explores pre-post changes in depression, anxiety, and executive functioning separately for male and female participants.



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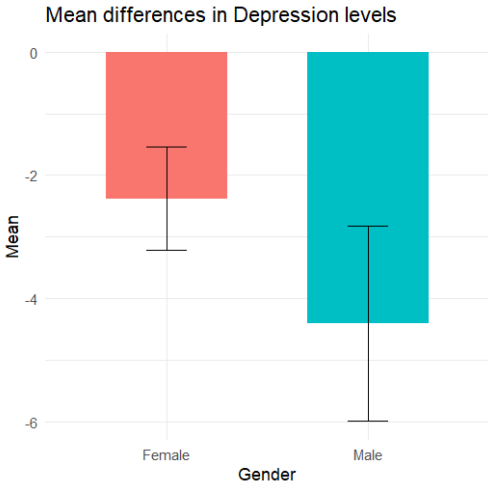
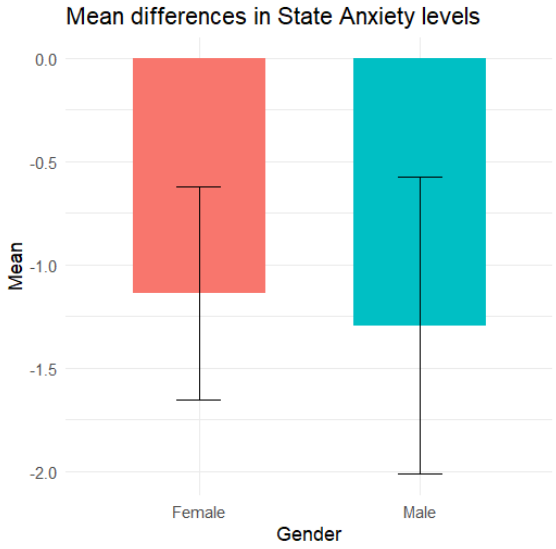
### 4.3.1 - Depression

Gender differences emerged in the reduction of depressive symptoms following the intervention. Both male and female participants showed improvements, but the decrease was greater in males (Δ = -4.41, SE = 1.59) compared to females (Δ = -2.38, SE = 0.84). This finding aligns with previous research indicating that biological sex can influence the neuroendocrine and emotional responses to stress-reduction strategies (Albert, 2015). Specifically, men and women may exhibit different patterns of hypothalamic-pituitary-adrenal (HPA) axis regulation and serotonergic functioning, contributing to varied emotional reactivity and recovery from depressive states (Bekhbat & Neigh, 2018).




### 4.3.2 Anxiety




For anxiety symptoms, reductions were observed across both genders, with a slightly larger mean change in males (Δ = -1.29, SE = 0.72) compared to females (Δ = -1.14, SE = 0.52). Although the difference between genders was less pronounced than for depression, this pattern is consistent with studies showing that men may experience greater acute physiological relief from stress-related interventions, possibly due to differences in autonomic nervous system reactivity (Dearing et al., 2022). Nonetheless, both sexes benefitted from the practices, suggesting that cold exposure and breathwork are broadly effective across gender lines for managing anxiety.

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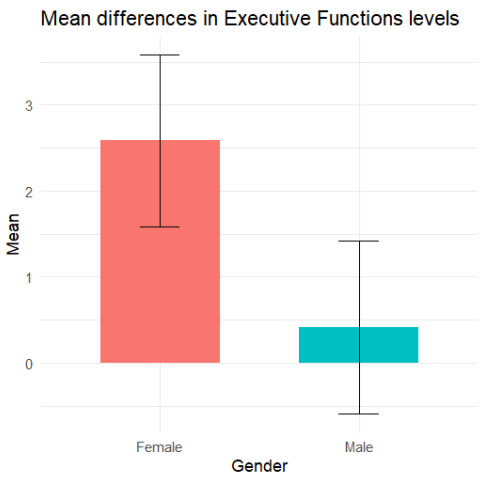


### 4.3.3 Executive Functions

In contrast to mood-related variables, improvements in executive functioning were more substantial in females (Δ = +2.59, SE = 1.00) than in males (Δ = +0.41, SE = 1.01). This aligns with prior evidence suggesting that women, particularly in midlife and older adulthood, may experience greater cognitive plasticity in response to interventions that challenge attention and self-regulation capacities (McCarrey et al., 2016; Yuan & Raz, 2014). These differences could reflect both neurobiological factors, such as hormonal modulation of the prefrontal cortex, and psychosocial factors, including differential engagement in cognitively stimulating activities.

## 4.4 Differences Between Age Groups

### 4.4.1 - Depression

At the start of the program, participants in the 45–59 age range reported significantly higher levels of depression compared to those over 60 (**F = 15.61, p < 0.001**). This finding is not surprising, as midlife is often a psychologically demanding period. Many individuals in this age group experience chronic stress due to work pressure, caregiving roles, financial responsibility, and the early signs of physical decline. These factors often go unrecognized but can contribute to a gradual erosion of emotional resilience.

What is particularly encouraging is that the same group who started in a worse emotional state also showed the greatest improvement by the end of the training (**F = 4.96, p = 0.03**). This suggests that the COL.D.D. intervention may be especially well-suited to support adults in midlife who are beginning to feel emotionally fatigued or overwhelmed. The structured nature of the training, regular sessions, body-mind integration, and gradual exposure to challenge, may provide precisely the kind of support this group lacks in daily life. It reinforces the idea that midlife may represent a "turning point" where preventive strategies can be especially impactful.

### 4.4.2 Anxiety

A similar pattern emerged with anxiety. Participants in the middle-aged group started the program with higher levels of state anxiety (F = 11.66, p < 0.001), once again highlighting the emotional weight that often accompanies this life stage. However, unlike with depression, the program's effectiveness in reducing anxiety was equally distributed across age groups. Both middle-aged and older adults experienced a clear reduction in anxious symptoms, and the overall effect of the intervention was statistically significant (F = 7.89, p = 0.007).

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This equal response may reflect the universality of anxiety as an emotional state. While younger participants may feel more tension due to time pressures, older adults can experience anxiety in the form of health-related worries, social loss or fear of dependency. The mindfulness and breathing components of the training likely provided all participants—regardless of age—with practical tools to regulate their internal state and reduce physiological arousal. The cold-water immersion, meanwhile, may have acted as a "reset" mechanism, helping participants build tolerance to discomfort and stress.

### 4.4.3 Executive Functioning

Interestingly, when it came to executive functioning both age groups started at **similar levels** (**F = 0.11, p = 0.74**). This finding challenges the common assumption that older adults always perform worse on tasks of cognitive control. In fact, some research suggests that with adequate stimulation and lifestyle habits, older adults can maintain stable executive functioning well into their 70s or even 80s (Nyberg et al., 2012)

There was a **small but meaningful overall improvement** after the intervention (**F = 3.99, p = 0.04**), showing that cognitive skills can be preserved or slightly enhanced even in non-clinical, aging populations. However, there were **no significant differences** in improvement between the two age groups, indicating that the intervention worked equally well for both. This may be due to the nature of the training itself: the combination of physical challenge (through cold exposure) and attentional practice (via mindfulness) engages executive processes broadly, regardless of baseline ability.

These results are encouraging because they suggest that simple, low-cost practices can help **preserve mental sharpness** across a range of ages, whether someone is navigating midlife stress or adjusting to later-life transitions.

## 4.5 Differences Between Countries

In addition to exploring how age influenced the results, it was also examined whether participants' country of residence played a role in how they responded to the COL.D.D. program. This analysis was important because each participating country has distinct cultural attitudes toward mental health, cold-water exposure, and mindfulness practices. Moreover, the social and healthcare environments in these countries differ, which could influence baseline well-being and openness to this type of intervention.

By comparing changes in depression, anxiety, and executive functioning across countries, the COL.D.D consortium aimed to explore whether the program's effectiveness was consistent or whether some regions showed greater improvements than others. These comparisons provide useful insights into the cultural adaptability of the COL.D.D. model and offer guidance for future cross-national applications.

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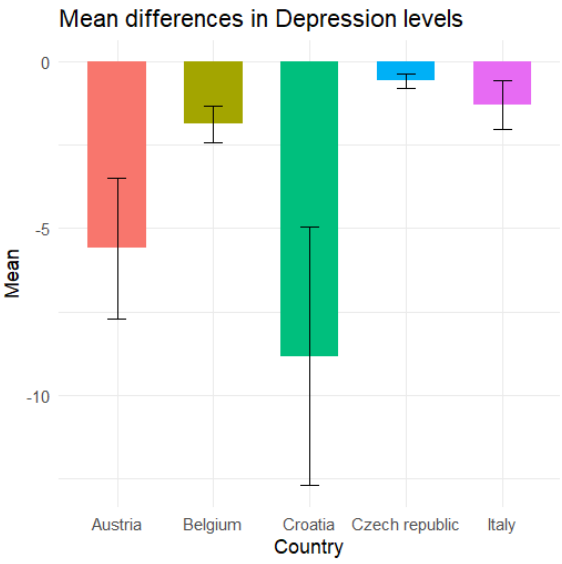
### 4.5.1 - Depression




When comparing changes in depressive symptoms across countries, the COL.D.D. program's impact varied significantly, suggesting that cultural and contextual factors may shape outcomes.

**Croatia** emerged with the largest reduction in depression (ΔM = –8.83), indicating a particularly strong response. Eastern European countries, including Croatia, often report higher baseline rates of depression due to economic stress and limited mental health access, making interventions like COL.D.D. especially impactful in these contexts (Eurostat, 2022). Community-based, non-pharmacological interventions have been shown to be especially effective in such settings, where clinical services may be less accessible (Giebel et al., 2022).

**Austria** also showed a substantial decrease (ΔM = –5.60). The cultural familiarity with wellness activities—such as alpine hiking, thermal baths, and nature-based therapies—likely enhanced receptiveness to cold-water immersion. In Austria and other Central European countries, regular outdoor exposure is associated with reduced depressive symptoms, particularly among those with limited access to conventional psychological support (Pasanen et al., 2019). **Belgium** (ΔM = –1.88) and **Italy** (ΔM = –1.30) saw more modest improvements. These may reflect a relatively lower baseline burden of depression combined with broader access to mental health care and wellness practices. Cultural approaches in Southern and Western Europe often prioritize therapeutic and social forms of mental health support, which may overshadow the impact of physical challenge-based interventions like cold immersion. (Sadeniemi *et al.* 2018) The **Czech Republic** showed the smallest reduction (ΔM = –0.58), potentially due to existing cultural norms around cold immersion (e.g., winter swimming), meaning the intervention offered less novelty. However, the country's relatively stable baseline mental health and supportive community norms may have limited observable gains.

### 4.5.2 - Anxiety

When looking at how anxiety levels changed across countries, it was again observed some variability in the program's impact. While all participants generally showed reduced anxiety, some countries experienced larger improvements than others.

Participants from **Croatia** experienced the most significant decrease in anxiety (ΔM = -8.83). This aligns with the depression results and may suggest that participants from Croatia began the program with higher emotional vulnerability. Social and economic factors in Eastern Europe, including financial stress and limited psychological services, have been associated with elevated

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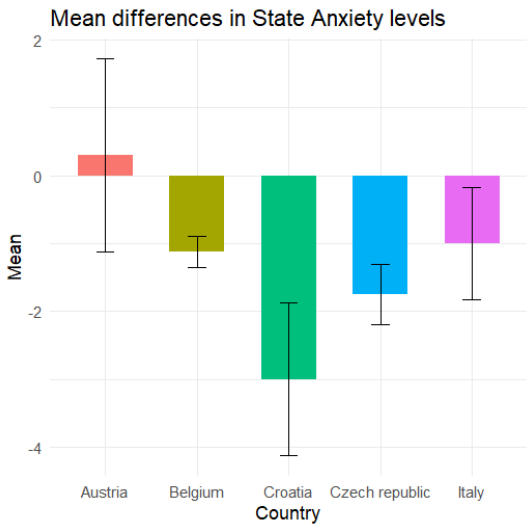


anxiety rates among adults (Eurostat, 2022). The strong response to the COL.D.D. training could indicate that this population particularly benefited from the stress-regulation techniques offered by the program.

**Austria** also reported a considerable reduction in anxiety (ΔM = -5.60). This likely reflects a cultural familiarity with outdoor challenge-based activities such as alpine sports, thermal bathing, and seasonal cold exposure, all of which support mental toughness and emotional regulation. Literature on recreational outdoor activity in Central Europe shows that regular physical and nature-based practices significantly reduce physiological markers of anxiety (Pasanen et al., 2019).

By contrast, reductions in anxiety were more moderate in **Belgium** (ΔM = -1.88) and **Italy** (ΔM = -1.30). This pattern may reflect a combination of lower baseline anxiety and cultural attitudes less oriented toward physical "discomfort" as a wellness strategy. In more urbanized or Southern European contexts, mindfulness and stress reduction are often approached through less physically demanding practices, which might explain why the cold-water exposure component had a smaller impact.

Finally, participants from the **Czech Republic** reported the smallest reduction in anxiety (ΔM = -0.58). This is somewhat surprising given the country's winter swimming culture, but it could suggest that Czech participants were already accustomed to cold exposure and thus experienced less novelty, and perhaps less of a stress-buffering effect from the training.

Taken together, these results suggest that the COL.D.D. project may be particularly effective in contexts where people either face higher emotional stress or are culturally receptive to physical challenge as a form of emotional release.

### 4.5.3 - Executive Functioning

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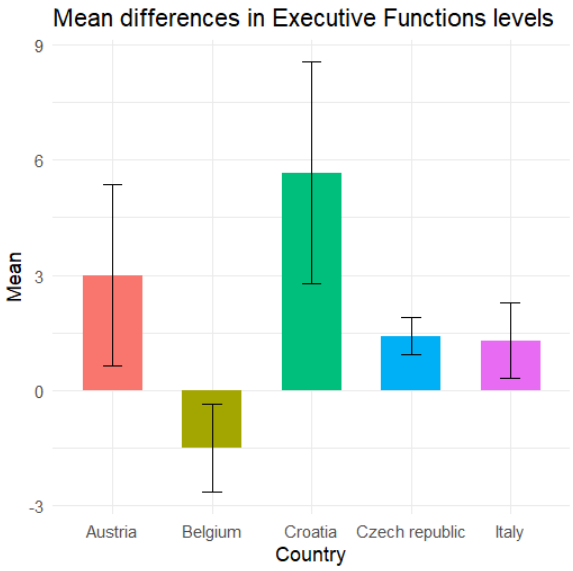
The improvements in executive functioning across countries followed a different pattern, suggesting that cognitive gains may be shaped by factors distinct from those affecting mood.




Participants from **Croatia** again showed the greatest improvement in executive functioning (ΔM = 5.67). This may indicate that in addition to emotional relief, the COL.D.D. practices helped restore mental clarity and organizational skills in participants whose cognitive functioning may have been compromised by chronic stress. Chronic stress and mood disorders are known to impair executive functioning, and interventions that address both emotional and physiological resilience often lead to cognitive recovery (Liston et al., 2006).

**Austria** also showed a positive improvement (ΔM = 3.00), suggesting that their wellness-oriented culture may support cognitive benefits through combined physical and mental activities. Practices such as mountain sports, which require planning and focus, may have created a fertile ground for further executive functioning enhancement through mindfulness and cold exposure.

In **Italy** (ΔM = 1.30) and the **Czech Republic** (ΔM = 1.42), the improvements were positive but smaller. These changes might reflect general cognitive stimulation gained from regular practice, though perhaps the initial executive functioning in these groups was already adequate, leaving less room for measurable improvement. Alternatively, the mindfulness practices may have been sufficient to sustain daily cognitive skills without causing dramatic change.

Interestingly, **Belgium** showed a slight **decline** in executive functioning scores (ΔM = -1.50). This unexpected result could have several explanations. It is possible that Belgian participants, initially more cognitively active due to work or lifestyle habits, found the structure of the intervention less stimulating cognitively, focusing more on emotional regulation than on mental challenge. Another explanation could be statistical noise due to the relatively small sample sizes.

The data suggests that executive functioning improvements were most prominent in regions where either the cognitive burden of daily life was higher, or where participants faced greater initial stress, impairing their cognitive clarity. The training seems to have acted as a “reset,” helping restore mental sharpness where it was most needed.

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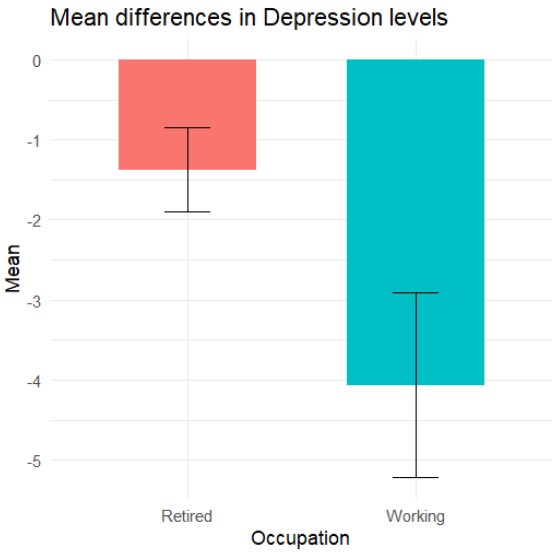
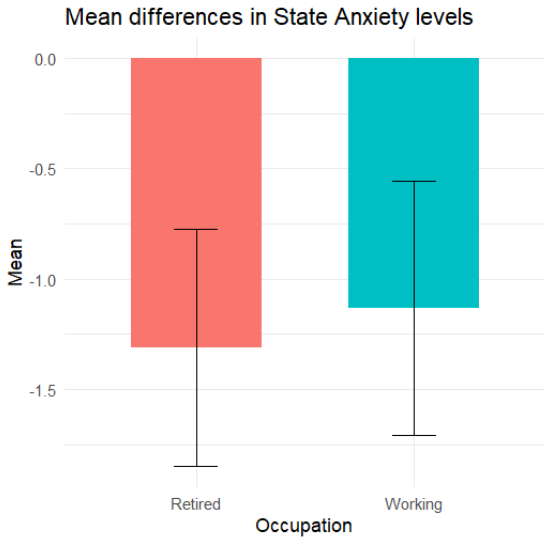
## 4.6 Differences Between Occupations

Occupational status is another important factor influencing mental health outcomes in later life. Work can provide structure, social contact, and cognitive stimulation, while retirement may offer freedom but also carries risks of social withdrawal and reduced mental engagement (Bonsang et al., 2012; Kim & Moen, 2002). The following section examines how being employed versus retired shaped participants' responses in depression, anxiety, and executive functioning measures.

### 4.6.1 - Depression

When examining depression scores, occupational status appeared to influence the observed changes. Working participants showed a more substantial reduction in depressive symptoms (**M = -4.07, SE = 1.15**) compared to retired participants (**M = -1.38, SE = 0.52**). This finding aligns with prior research indicating that employment, by providing structure, social interaction, and a sense of purpose, often serves as a protective factor against depression in older adults (Van der Noordt et al., 2014). In contrast, retirement, while potentially reducing stressors related to work, can sometimes lead to loss of routine and diminished social engagement, factors associated with increased vulnerability to depressive symptoms, particularly in the absence of meaningful post-retirement activities (Segel-Karpas, Ayalon, & Lachman, 2018).




### 4.6.2 Anxiety

For anxiety, changes were relatively similar across groups, though slightly greater reductions were observed in retired participants (**M = -1.31, SE = 0.54**) compared to working participants (**M = -1.13, SE = 0.57**). This could reflect that retirement may reduce certain work-related stressors contributing to chronic anxiety, such as job demands and time pressures (Kim & Moen, 2002). However, the differences between the groups were small, suggesting that cold exposure and breathing practices may exert similar anxiety-reducing effects regardless of occupational status.

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### 4.6.3 Executive Functions

In the domain of executive functions, employed participants demonstrated a markedly greater improvement (**M = 2.60, SE = 1.02**) compared to their retired counterparts (**M = 0.25, SE = 0.86**). This difference may be related to the ongoing cognitive demands and engagement inherent in working life, which can help maintain or enhance executive function in older adults (Boot et al., 2015; Fisher et al., 2014). In contrast, retirement can sometimes be associated with cognitive underuse, although outcomes vary widely depending on how retirees structure their daily activities (Bonsang, Adam, & Perelman, 2012).


## 4.7 Qualitative Analysis

The qualitative results of the COL.D.D. project revealed clear differences across the five participating countries, both in how participants described their emotional and functional well-being and in how these experiences aligned, or diverged, from the quantitative data on depression, anxiety, and executive functioning. This comparison highlights the relevance of cultural context, baseline lifestyle habits, and subjective interpretations of well-being.

**Belgium**

In Belgium, participants reported stable emotional well-being, with mood described as neutral or slightly positive throughout the program. No substantial changes were noted in daily functioning, orientation, or mobility, as participants already maintained independent lifestyles. Energy and sleep patterns showed minor improvements, but some participants continued to report persistent sleep difficulties. Recurring thoughts and emotional worries remained stable and low, and physical activity did not increase significantly, with barriers such as lack of time still present.

These qualitative reports are consistent with the quantitative data, which showed only modest reductions in depression and anxiety. Executive functioning remained largely unchanged. The limited change in Belgium suggests that the participants either started with a relatively stable mental state or engaged less deeply with the intervention's more physically demanding components, such as cold-water immersion. Cultural tendencies in Belgium may favor cognitive or conversational coping strategies over body-based practices, potentially limiting the perceived benefits of such an intervention.

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**Italy**

Italian participants presented a nuanced emotional profile. While many reported pre-existing resilience through active lifestyles and caregiving responsibilities, others described chronic anxiety and emotional vulnerability. Post-intervention, their mood remained largely stable, reflecting both a high level of coping skills and a persistence of certain emotional challenges. Daily functioning and mobility were already high pre-intervention and did not change. Energy levels were moderate to good, although sleep disturbances remained for some participants. Recurring thoughts often centered on caregiving concerns or grief but were managed through pre-existing coping strategies. Physical activity, already part of daily life for many, was sustained or slightly increased.

Quantitative results from Italy reflected these qualitative findings: changes in depression and anxiety were modest, and executive functioning showed only minor improvements. This suggests that the COL.D.D. program functioned more as reinforcement of existing habits rather than as a transformative intervention. The cultural familiarity with mindfulness and social support, alongside less enthusiasm for cold-water immersion, may have further shaped these outcomes.

**Czech Republic**

In the Czech Republic, participants reported slight mood improvements, which they attributed to outdoor activities and seasonal changes. Their daily routines and independence in orientation and mobility remained stable. Sleep and energy showed minor positive changes, often linked to increased time spent in nature. Recurring thoughts and emotional concerns were minimal both before and after the intervention. Physical activity was already a strong part of their lifestyle and was further enhanced through cold-water swimming.

Interestingly, the quantitative data did not reflect these positive subjective experiences, showing minimal changes in depression, anxiety, or executive functioning. This suggests a discrepancy between subjective well-being—improved by lifestyle engagement and outdoor enjoyment—and clinically measurable emotional distress. The Czech participants, accustomed to winter swimming and outdoor movement, may have experienced the program as a pleasant reinforcement of existing wellness habits, rather than a major therapeutic shift.

**Croatia**

Croatian participants exhibited some of the most positive changes across all dimensions. Mood shifted toward greater energy and optimism following the intervention. Daily functioning remained independent but became more enjoyable. Orientation and mobility were stable, with some participants reporting an increased desire to be active outdoors. Energy levels improved, although sleep difficulties persisted for some. Recurring thoughts of distress were initially low and further diminished after the intervention. Physical activity increased markedly, particularly cold-water swimming, which was adopted regularly by many participants.

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These qualitative improvements aligned closely with the quantitative results: Croatia showed the largest reductions in depression and anxiety and the most pronounced improvement in executive functioning. This coherence suggests that the intervention successfully addressed unmet needs for emotional regulation and cognitive engagement. Given the higher baseline mental health challenges reported in Croatia in broader European health surveys, the COL.D.D. program may have filled a gap in accessible, community-based mental health support.

**Austria**

In Austria, participants reported increased mood stability and greater enjoyment in daily life, particularly regarding outdoor activities. Orientation and mobility remained high, and some participants expressed renewed motivation to spend time outdoors. Sleep and energy improved modestly, linked to regular movement and mindfulness practices. Recurring thoughts were not a major concern and diminished further during the program. Physical activity clearly increased, with participants valuing both the cold-water component and the structured mindfulness.

Quantitatively, Austria showed notable improvements in depression scores and moderate improvements in anxiety and executive functioning, aligning well with the qualitative data. Austria's strong wellness culture, emphasizing hiking, nature, and outdoor sports, likely facilitated participants' engagement with the intervention and helped amplify its benefits.

**Comparative Summary**

Taken together, the data show a strong coherence between subjective reports and clinical outcomes in countries where the intervention either addressed existing vulnerabilities (Croatia) or complemented wellness-oriented lifestyles (Austria). In these contexts, both mood and energy improved, sleep stabilized somewhat, and physical activity increased substantially, particularly cold-water swimming.

Conversely, in Belgium and Italy, where baseline emotional distress was lower and coping strategies were already in place, the intervention resulted in minimal change. This stability was reflected both in participants' self-reports—where they described maintaining their routines with little emotional shift—and in the modest changes in depression, anxiety, and executive functioning. In these cases, cultural factors and lifestyle habits may have limited the novelty and impact of the intervention.

The Czech Republic presented a notable divergence: despite reporting subjective improvements in well-being, outdoor enjoyment, and physical activity, participants' clinical scores remained largely unchanged. This highlights the distinction between improvements in subjective quality of life and changes measurable through standardized questionnaires—a finding supported by prior research on lifestyle interventions and well-being (Pasanen et al., 2019; Ryff, 2014).

Across all countries, daily functioning and mobility were stable at a high baseline, suggesting the sample was composed of relatively independent and active adults. Physical activity was the most



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consistently improved domain, particularly in Croatia, Austria, and the Czech Republic, where the practice of cold-water swimming resonated with either unmet needs or pre-existing cultural practices. Sleep improvements and reductions in recurring negative thoughts were present but uneven across the sample.

In conclusion, the cross-country analysis demonstrates that the COL.D.D. intervention had the greatest impact where it either filled a gap in emotional support (as in Croatia) or reinforced active, wellness-based lifestyles (as in Austria). Where such support was already in place, as in Belgium and Italy, the program had a stabilizing rather than transformative effect. These findings emphasize the importance of tailoring mental health interventions to cultural and lifestyle contexts and of evaluating both clinical and subjective outcomes when assessing program effectiveness.

## 5. Discussion

The results from the intervention clearly show that a simple, natural approach like combining mindfulness and cold-water immersion can have a positive effect on how people feel and think, especially as they get older. In a time when many people face mental health struggles and cognitive decline as they age, finding low-cost and accessible solutions is more important than ever.

The most noticeable change in the participants was the drop in depressive symptoms, especially among those in their midlife years. These individuals started the program with higher levels of depression, and their scores improved the most. This makes sense: midlife is often filled with stress from work, caregiving duties, and health concerns. Practicing mindfulness and gradually getting used to cold water might have helped them relax more, clear their minds, and regain emotional balance. This finding reflects what was known from other research: both mindfulness and cold exposure can reduce the production of stress hormones like cortisol and increase mood-boosting chemicals such as endorphins and noradrenaline (Shevchuk, 2008; Kox *et al.*, 2014).

The program also helped participants manage anxiety better. Many participants, especially those in the middle-age group, felt tense or on edge at the beginning. But by the end, they reported feeling more calm and in control. This improvement was shared by both younger and older participants, which is encouraging. It suggests that this kind of training can be helpful for a wide range of people, regardless of age. Other studies have shown that controlled breathing and exposure to cold stimulate the vagus nerve, which helps slow down the heart rate and activate the body's relaxation system (Cain *et al.*,2025).

When it comes to cognitive functioning, things like self-monitoring, attention, and planning, there was also some progress. While the improvement wasn't as strong as with mood-related symptoms, it was still a step in the right direction. These are abilities that usually get worse with age, so even a small gain is a good sign. Since the results came from self-report questionnaires, it is possible that more precise tests in future research could show even clearer benefits.

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One of the strengths of the COL.D.D. project was that it worked across five countries, with people from different backgrounds. The fact that all 46 participants completed the full 10 workshop cycle shows that the program is not only effective but also doable and engaging. This is important considering the possibility of bringing this kind of approach into community centers, wellness programs, or public health initiatives.

It is important to acknowledge certain limitations of the study. First, the absence of a control group limits the ability to determine whether observed improvements were directly attributable to the training program or influenced by other external factors. Additionally, the sample size was relatively small and not fully representative in terms of gender distribution and educational background, which may affect the generalizability of the findings. Furthermore, as data were self-reported by participants, there is potential for response bias, which could influence the accuracy and objectivity of the results.

Still, the findings are promising. The COL.D.D. project offers a model that could be used and adapted in many settings to help people age in a healthier and more positive way. By mixing physical challenge (cold exposure) with mental focus (mindfulness), the program equips participants with effective strategies for managing stress and maintaining cognitive clarity; skills that are beneficial at any age.. The results of the COL.D.D. project provide valuable insight into how non-pharmacological interventions such as mindfulness training and cold-water immersion can support mental well-being and cognitive functioning in older adults. These findings align with growing international interest in low-cost, accessible approaches to active and healthy aging.

One of the most promising outcomes was the significant reduction in depressive symptoms among participants. The data suggests that the intervention was particularly beneficial for middle-aged adults, who started the program with higher baseline levels of depression. This finding supports previous research indicating that midlife is a particularly vulnerable period for emotional distress, potentially due to career pressure, caregiving responsibilities, and physical health changes. The combination of mindfulness and cold-water immersion likely provided both emotional relief and physiological stimulation, helping participants regulate their mood and reduce psychological strain.

Anxiety levels decreased significantly across the entire sample. Though middle-aged participants again showed higher initial levels of anxiety, the program was equally effective for both age groups. This suggests that the stress-relieving effects of mindfulness and breath control, combined with the adaptive challenge of cold exposure, can foster a sense of emotional control and confidence across different life stages. The ability to manage anxiety is especially relevant in older populations, as chronic stress has been linked to both physical illnesses and cognitive decline.

Regarding executive functioning, while improvements were more modest, they were still meaningful. The observed gains in attention, planning, and mental flexibility are encouraging, particularly because these skills tend to decline gradually with age. Although no age group



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differences emerged here, this may indicate that cognitive improvements are accessible to a broad population, regardless of initial ability. It is also worth noting that the executive functioning questionnaire was self-reported, which might have limited the sensitivity of the results. Including objective neuropsychological tests in future studies could provide a more detailed picture.

These results support the effectiveness of combining physical and mental practices to enhance psychological resilience and daily functioning. The program's structure, regular sessions, professional guidance and gradual progression, likely contributed to its impact. Importantly, the approach was both inclusive and feasible: participants from five countries, many of whom were retired or socially isolated, fully engaged in the process and completed all sessions. This points to the potential for broader community application, particularly in public health and social care settings.

However, some limitations should be considered. The absence of a control group limits the ability to attribute improvements solely to the intervention. The sample was also relatively small and uneven in terms of gender and educational background. Future studies should include more diverse participants and longer follow-up periods to assess the durability of benefits over time.

Despite these limitations, the COL.D.D. project offers a promising, replicable model for improving emotional and cognitive well-being through integrated mind-body training. It underscores the value of prevention-focused programs that empower individuals to take an active role in maintaining their mental health well before clinical symptoms become severe.

With the academic support of the University of Palermo, acting as an associated partner, and through the joint efforts of all project partners, a scientific article was developed to present the key outcomes and methodology of the COL.D.D. intervention. The manuscript was submitted to the peer-reviewed journal *Frontiers in Public Health*, where it is currently under review. This collaborative work reflects the multidisciplinary approach of the consortium and aims to contribute to the international discourse on body–mind interventions for the prevention of depression, anxiety, and cognitive decline in aging populations. Further information on the journal can be found at the following link: https://www.frontiersin.org/journals/public-health.



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